PowerGuard Lean Manufacturing – Phase I Accomplishments

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ABSTRACT

This paper describes the advances made by PowerLight during the first year of work under the PV:Manufacturing R&D contract. The overall technical goal of this project was to reduce the cost of PowerGuard manufacturing while simultaneously improving product quality. This will enable PowerLight to scale up production capacity as the market for PowerGuard continues to grow.

Through the introduction of World Class Lean Manufacturing techniques, PowerLight was to cut out waste in the manufacturing process of PowerGuard. The manufacturing process was to be overhauled with an objective of removing as much as possible those steps, which do not add value to the product. Quality of finished goods was also to be improved through the use of Statistical Process Control and error-proofing in the manufacturing process. Factory operations were also to be addressed in order to streamline those factory activities which support the manufacturing process.

1. General Introduction

The purpose of this contract was to make improvements to the manufacturing process of PowerGuard, PowerLight's building-integrated photovoltaic roofing tile. Through the implementation of Lean Manufacturing principles, PowerLight worked to achieve the project goals of reduced product cost, improved product quality, and increased manufacturing capacity in order to keep up with growing demand.

The efforts to reduce cost focused on the reduction of product lead time and the elimination of wasted material and labor. Yield improvements were achieved through error-proofing of various parts of the manufacturing process and the implementation of quality metrics and statistical process control. Improvements were also made to the ancillary factory systems to reduce unnecessary clean-up and material waste.

2. Lead Time Reduction

We have defined product lead time as the amount of time between the arrival of raw materials and the completion of finished goods. The activities which are performed in the process of going from raw materials to installed product can be divided into two categories: value-added and non value-added. Value-added activities are those that add something for which the customer is willing to pay. In the ideal case, all non value-added activities are eliminated, thus optimizing the use of resources and the responsiveness of the company to customers' needs. In reality, there will probably always be some non value-added activity required. The objective is to reduce the non value-added portion of product lead time to a practical minimum.

At the start of this project, an audit was performed of the existing manufacturing process to accurately assess the product lead time. As expected, most of the product lead time was due to the curing requirements of the coating and adhesives used in the production process. The greatest gains could be made by reducing these curing times. Additional small gains could be made by reducing any batch processes and transitioning to continuous flow of materials.

PowerLight worked to balance the throughput of various parts of the production process in order to reduce batching. The installation of a second CNC router increased the capacity of the routing process so that it could keep up with the coating process. Simultaneously, the coating process was slowed down slightly to match the speed of the routing process. This eliminated the need to rout all the foam boards prior to starting the coating process. This reduced the floor space requirements, eliminated the wasted labor of stacking and unstacking the routed boards, and also helped to reduce scrap by providing less exposure of the routed boards to damage from handling.

To achieve drastic reductions in product lead time, PowerLight focused on changing the PowerGuard product to improve its manufacturability. The primary focus of this change has been to reduce curing times as much as possible. Since most of the curing time required is for the coating, PowerLight began investigating alternatives to the current coating. A sheet metal cover was developed using an adhesive which cuts the curing time from 72 hours to six minutes. Additionally, in the PowerGuard tiles with sloped PV modules, the adhesive for the PV module was replaced with mechanical fasteners, completely eliminating a curing step. Manufacturing of the new product design lends itself very readily to a continuous flow operation. When manufacturing the sloped PV tiles, the product lead time is 13 minutes, which is less than 10% of the original lead time. With a horizontal PV module, the product lead time on the new production line will be reduced to just over 24 hours or 25% of the original lead time.

A small assembly line was set up at the back of the PowerLight factory to produce the new PowerGuard design. Due to space limitations, it was set up with a fairly low throughput. This throughput can be increased when additional space becomes available by increasing the length of the conveyor line and by improving the assembly tools for the workers. The major pieces of equipment were sized for the higher throughput level anticipated in the future.

Once the major components of the new assembly line were in place, PowerLight ran several small pilot runs to test out the process and the new parts. Factory workers were

trained in the new assembly process, and production units began rolling off the assembly line in early February, 2003. Figures 1, 2, and 3 show the new production line in operation.

Figure 1. Adhesive application

Figure 2. Lamination

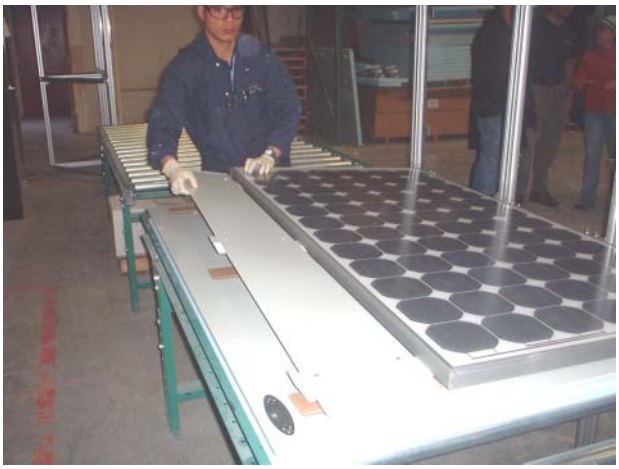

Figure 3. Final Assembly

Figure 4. Completed stack ready to package for shipping

2. Yield Improvements

At the beginning of this contract, PowerLight was focusing yield improvement efforts on the existing PowerGuard design. With the implementation of the new PowerGuard production line, the long term focus of quality improvements has shifted to the new PowerGuard design.

The incorporation of error-proofing and statistical techniques resulted in an improvement in product quality. The original rejection rate of 1% or 10,000 parts rejected per million produced was improved to 0.6% or 6,000 parts rejected per million produced (PPM). The original target of 0.5% or 5,000 PPM was closed in to within 0.1% or 1,000 PPM. It is anticipated that we will achieve or exceed our goal after we fully implement the new quality system for PowerLight Corporation.

A nonconformance reporting process has been developed to establish metrics on supplier, in-process and field performance. This data is only just beginning to be compiled into a closed-loop corrective action system which will provide a basis for reducing process variability and rejections. Additionally, Statistical Process Control (SPC) has been applied to the new PowerGuard manufacturing process. PowerLight is measuring the capability of the process by using SPC on the critical design features. A process is considered capable when the variation in critical design features is below the required threshold. Once a process is shown to be capable, it will reliably produce parts within the required tolerance. The information is fed back into the manufacturing process to reduce variability and material rejections. Valuable process control and capability studies have been performed on all of the metal parts. This has resulted in adjustments to the process, specification or design to improve yield. PowerLight will continue to develop this process to reduce variability.

2. Factory Operations Improvements

PowerLight worked to reduce the cost of factory operations in several different ways. A new quality assurance system was created. The production process was changed to become more of a pull system to minimize inventory levels. Changes were made to help with factory organization and cleanliness to minimize the amount of labor spent maintaining the factory work space.

Additionally, improvements were put in place to increase the safety of the workers.

PowerLight has worked to change the factory operation from a series of batch operations to a continuous flow. The ultimate goal is to have a system where each operation has a staging position which is used to signal the process immediately upstream when a new part is needed for processing. This creates what is known as a pull system. Each station produces a new part only when the station immediately downstream needs one. With the launch of the new production line, PowerGuard production becomes a true pull system. It is anticipated that this will reduce the level of work-in-process (WIP) inventory by 94%. Similarly floor space required will be reduced by approximately 78%.

PowerLight installed a new dust collection system which will help to reduce cost. By more efficiently collecting XPS waste, the new system will minimize labor spent to clean up the equipment and the work area. Through better containment of the XPS dust, the maintenance requirements of the equipment will be reduced, and the equipment will be less prone to failure.

PowerLight commissioned an investigation into the noise and dust exposure of the factory workers. It was determined that the size of dust particles generated in the factory do not pose any health risks, though they can effect the comfort level of the workers. As a result, all workers who work in the vicinity of the XPS processing equipment are now provided with dust masks. It was also determined that the noise level due to the routers was too high for long term exposure. The workers were provided with suitable hearing protection based on their proximity to the routers. A noise attenuation enclosure was purchased and is scheduled to be installed around the two routers. This will make it unnecessary for any of the workers other than the router operator to wear hearing protection.

A new Quality Assurance program has been created to provide quality assurance in receiving, in-process and final inspection activities. This program follows ISO-9001 guidelines.

4. Summary of Accomplishments

Over the course of the first phase of the contract, many improvements have been made in the production of PowerGuard tiles. Most significantly, the development of a new design of PowerGuard tiles has greatly improved the manufacturability of PowerGuard creating the potential for drastic reductions in cost. The significant improvements made possible through this PV Manufacturing R&D contract are as follows:

- The creation of an analytical model of the PowerGuard production process
- Reduction of product lead time of over 90% for the sloped PV PowerGuard tiles and 25% for flat PV PowerGuard tiles
- Error-proofing of various parts of the PowerGuard production process
- Reduction of reject rate for current PowerGuard production to 0.6%
- Implementation of a Quality Assurance/Quality Control program
- Implementation of a non-conformance and corrective action program
- Implementation of a new production line for the manufacture of the new PowerGuard tile design
- Reduction of WIP inventory of 17% and the anticipated reduction of 94% with the start of production of the new manufacturing line
- Reduction of floor space required per unit produced of 17% and the anticipated reduction of 74% with the start of production of the new manufacturing line.

PowerLight is committed to continuous improvement in manufacturing. We are proud of the progress we have been able to make due to the funding from the PV:Manufacturing R&D program. With the help of this program we are making significant progress in reducing the cost of photovoltaic systems.